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Faunal Studies of the Lower Jefferson Limestones

James L. Eymann

FAUNAL STUDIES OF THE LOWER JEFFERSON LIMESTONE

by
JAMES L. EYMANN

A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Geological Engineering

MONTANA SCHOOL OF MINES
Butte, Montana
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FAUNAL STUDIES OF THE LOWER JEFFERSON LIMESTONE IN SOUTHWESTERN MONTANA

By
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Introduction

The exact geologic age of the Jefferson limestone in Montana has not been definitely determined, other than it is probably of upper, but possibly in part of middle Devonian age. Although not of immediate or apparent economic importance, the determination of the exact age of the Jefferson limestone may be of much value in connection with the discoveries of large quantities of oil in Devonian strata in the northern Great Plains and, in particular, with the extensive deep drilling in northeastern Montana which is anticipated during the summer of 1951.

In an effort to find new information on this subject, the writer chose as a undergraduate thesis required for the degree of Geological Engineering at the Montana School of Mines, the study of certain lower Jefferson fossils known to be present in southwestern Montana. Fossils were collected by the writer from the lower 3 feet of the Jefferson formation in the Limestone Hills near Townsend, Montana, and from 75 feet above the base of the Jefferson formation near Logan, Montana. This thesis was intended originally to describe only the fauna at Townsend; however, as work progressed, it was decided to make collections elsewhere near the base of the Jefferson. As strata near the base of the Jefferson near Logan, were known to contain a fauna, work was done there. Lack of time and bad weather prevented collecting from other areas.

The Limestone Hills near Townsend are about two miles northwest of the townsite in T. 6 N., R. 1 E. (Fig. 1), midway between Helena and Three Forks, about two miles off of U.S. Highway 10N. Logan is 10 miles southeast of Three Forks on U.S. Highway 10S (Fig. 1), and the area, where the collections were made, is $1\frac{1}{4}$ miles northeast of Logan in a gully east of the power lines in T. 2 N., R. 2 E.

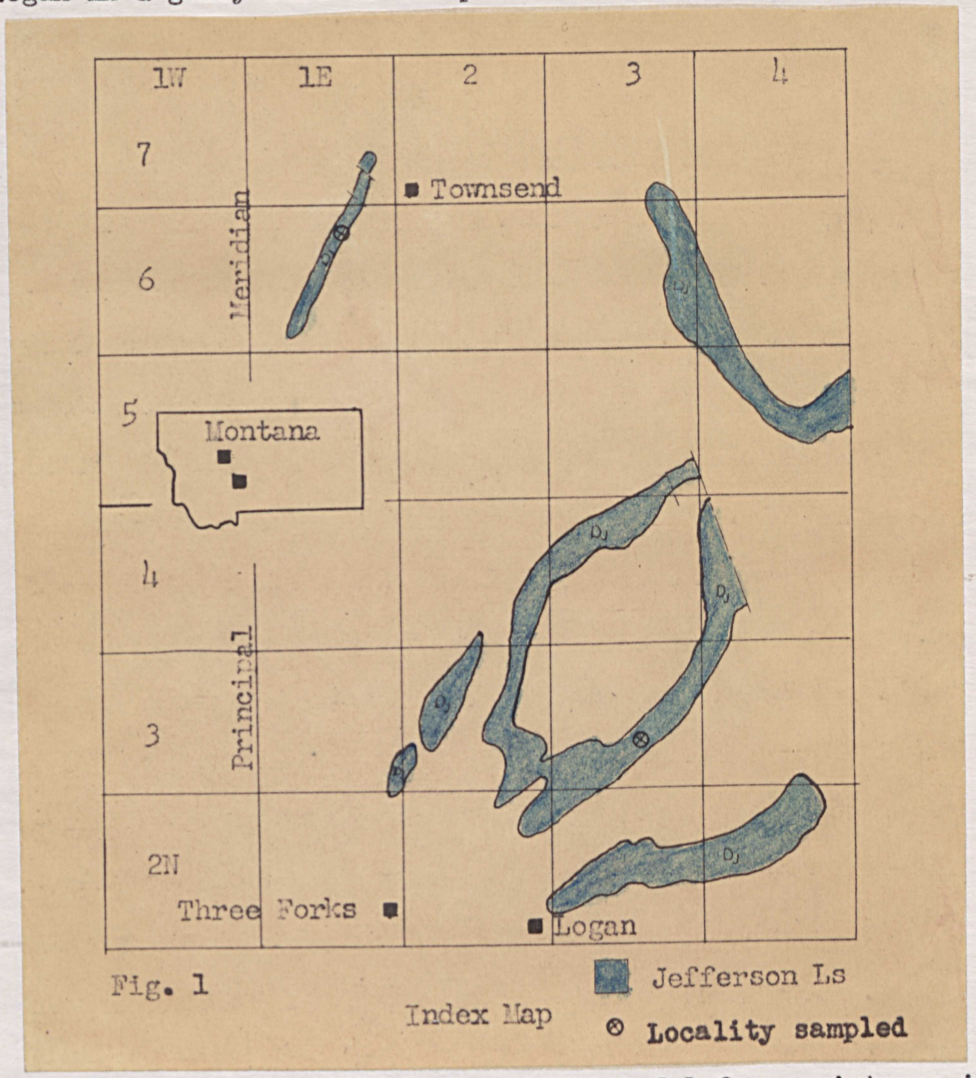

Fig. 1 Index Map

To Dr. E. S. Perry the writer is grateful for assistance in the preparation of this paper, and for help in taking photographs of the fossils collected. Acknowledgment is also made to Dr. Alvin Hanson, who suggested the areas, collected material at Townsend, and also helped in the preparation of this paper.

Previous Work

No previous work has been done on the fauna occurring at the base of the Jefferson in the Limestone Hills near Townsend, although the stratigraphy of this section has been studied by the Raynolds Expedition with F. V. Hayden (8) as geologist in 1860, by J. T. Pardee (14) in 1926, by A. V. Corry (4) in 1933, L. L. Sloss and W. M. Laird (18) in 1946, and by Edward T. Ruppel (17) in 1950. Ruppel prepared an "Open file" report for the U.S. Geol. Survey issued August, 1950, consisting of 86 pages of text and a detailed geologic map but did not describe the fossils.

Peale (16) in 1893 discussed the stratigraphy near Logan, as did Kindle (10) in 1908, but little detailed work was done in this area until 1943, when Berry (2) worked out the stratigraphy, and collected, 75 feet above the base of the Jefferson, the following fauna: Stromatoporoids, Spirifer cf. S. engelmanni Meek, Atrypa sp., Schuchertella cf. S. chemungensis Hall.

Work done in other areas in Montana near the base of the Jefferson includes that of Kindle (10), who collected from the lower 50 feet of the Jefferson in the Rock Creek section of the Philipsburg Quadrangle a fauna consisting of Schuchertella chemungensis var. arctostriata, Strophedonta cf. S. marcostriata, and Spirifer engelmanni; Haynes (9) found the coral, Favosites cf. F. limitaris Rominger, within the lower 25 feet of the Jefferson at Three Forks; and Sloss and Laird (18) did detailed work on the Jefferson throughout Montana, dividing it into Units A, B, C, from which they collected 32 fossils.

The Jefferson Formation

The Jefferson formation crops out in numerous localities throughout southwestern Montana, where it occurs frequently as ridges; however, eastward it is covered by younger rocks, and in the most southeastern

part of the state it is absent. This formation ranges in thickness from a few hundred feet to about one thousand feet.

The Devonian system in Montana was first studied at Three Forks, Montana, by Peale. Here he divided it into the Jefferson formation and the Three Forks formation. In designating the Jefferson, he stated:

> "In view of the fact that there is no apparent break in the continuity of the base from the top of the Cambrian to the top of the crystalline limestone, just above which the Devonian fossils occur in great abundance, I have given them throughout the name 'Jefferson Limestone'." (5, p. 44)

In general, the Jefferson is made up of an upper dolomitic member and a lower limestone member. The lower member is of particular interest to this paper because the fauna described herein came from this horizon. The limestone member rests unconformably on the so-called "Dry Creek" formation of upper Cambrian age.

In general, fossil forms are rare in the Jefferson formation in Montana. However, locally, and in certain zones, good identifiable fossils are present. The material gathered by the writer came from the two zones previously mentioned, both of which were thin and inconspicuous. The zone at Townsend occurs immediately above the brownish or rusty shales of the "Dry Creek" formation. The zone at Logan is in approximately the upper third of the limestone member with similar limestone beds above and below it.

The Montana Jefferson has been correlated in age with the Devils Gate of Nevada, the Minnewanka of Alberta, and the Naples Portage of New York. (12, p. 454)

The Fauna

The fauna collected from both Logan and Townsend consists of brachiopods, and in addition at Logan a small coral and a stromatoporoid were found. The fauna from Townsend, collected 3 feet from the base of the Jefferson by the writer, includes the following:

Spirifer engelmanni Meek
Cyrtina cf. C. triquetra (Hall)
Atrypa sp.
Atrypa missouriensis Miller
Athyris parvula Whiteaves

From the Logan section, 75 feet above the base of the Jefferson, the following specimens were collected:

Spirifer cf. S. jasperensis Warren
Schuchertella chemungensis var. arctostriata (Hall)
Favosites cf. F. limitaris Rominger
Clathrodictyon laxum Nicholson

The fauna from the Limestone Hills, though lower in the section from which other collections from the Jefferson were made compares favorably with those at higher horizons in other localities except for Cyrtina triquetra which although is an upper Devonian fossil, as yet is not known to have been found in Montana. Those collected from Logan agree with previous work done in this area, although the collection at hand does not include all the species previously described from this zone. In previous descriptions of these species there is considerable variation as to size, ornamentation of shell, and height of cardinal area. Tables were made by the writer to show the thickness, length, and width of shell, width and height of cardinal area, together with ratios of length to width of shell, length of shell to height of area, and height to width of area. The purpose of these tables is to give more detailed information in condensed form.

Systematic Paleontology

PHYLUM BRACHIOPODA

Superfamily SPIRIFERACEA

Genus Spirifer Sowerby, 1814

Spirifer engelmanni Meek

Plate 1, figs. A, B, C, D, E

1860. Spirifera engelmanni Meek, Proceed. Acad. Nat. Sci. Philad., XII, p.308.

1876. Spirifer engelmanni Meek, Col. Simpson's Report Exp. across the Great Basin of Utah, p.346, pl.1, figs.1a, b, c.
1884. Spirifer engelmanni Meek, Walcott, U.S. Geol. Survey Mon. 8, p.138.
1940. Spirifer engelmanni Meek, Merriam, Geol. Soc. America Spec. Paper 25, p.87, pl.8, figs. 3,4.

> Description--"Shell rather small, somewhat gibbous, subsemicircular, or approaching subtrigonal in general form, with the greatest breadth on the hinge-line; lateral extremeties rather acutely angular; anterior lateral margins with outline usually straightened and converging rapidly from the lateral extremeties to the middle of the front. Ventral valve more convex than other, its greatest prominence being at or near the beak, which is abruptly pointed and more or less uncurved; area generally rather high, well defined, and standing at nearly right angles to the plane of the valves, but always arching backward with the beak; foramen higher than wide; mesial sinus narrow and shallow, but extending to the apex of the beak, smoothly rounded within, and bounded on each side by a plication that is a little more prominent than any of the others; lateral slopes each occupied by about seven to ten simple costae. Dorsal valve moderately convex, the greatest convexity being near the middle mesial fold narrow, flattened, or more or less rounded, and, like the sinus of the other valve, without costae or plications; lateral slopes with costae as in the other valve; beak scarcely distinct from the cardinal margin. Fine surface markings and internal characters unknown. Length 0.57 inch; breadth, about 0.82 inch; convexity, about 0.50 inch." (11, p. 41)

Remarks--This is the most abundant spirifer found at Townsend. It is characterized by its high, curved cardinal area and lack of plications on both fold and sulcus.

The ventral valve is strongly subtriangular in shape, highest at the beak, with the surface sloping abruptly to the lateral and posterior margins. The sulcus extends from the beak where it is narrow, to the anterior margin where it is wide, shallow, and generally round to subround. Plications on the slopes of the valve are simple and round, averaging 10 to 12 in number, with the one next to the sulcus a little more prominent than the others. Standing at right angles to the hinge line of the valve, the cardinal area is triangular, high, and generally curved.

The dorsal valve is nearly flat with the greatest convexity at the middle. The fold is generally flat and increases in width from

the beak to the anterior margin. A few specimens show a median furrow in the fold. Plications are the same as those on the ventral valve.

An internal mold shows large, long teeth present, but other than this the internal features were not studied. Numerous ventral and dorsal valves were found, but only one complete specimen could be obtained which is deformed slightly and has an extremely high cardinal area. The dimensions of this specimen are as follows: length, 8.6 mm; width, 19.4 mm; thickness, 14.7; height of area, 13.0 mm; and width of area, 19.0 mm.

The table below shows the size and ratios of a number of ventral valves.

		Area			Ratios	
Length	Width	Height	Width	Length to Width	length shell to height area	length area to width area
8.9	17.8	7.6	13.9	2.00	1.17	1.83
10.7	17.6	8.1	17.3	1.65	1.32-	2.14
9.9	17.5	8.0	16.9	1.77	1.24	2.11
8.0	12.9	---	----	1.61	----	----
10.4	19.9	7.6	17.5	1.91	1.37	2.3
10.3	19.7	---	----	1.91	----	----
----	16.0	---	----	----	----	----
10.3	18.3	7.7	18.0	1.78	1.34	2.34
10.2	15.5	7.8	15.0	1.57	1.31	1.93
7.9	12.4	5.8	11.8	1.57	1.36	2.03
6.8	12.9	4.0	12.8	1.91	1.70	3.2
8.0	14.9	---	----	1.86	----	----
8.6	19.4	13.0	19.0	2.26	1.72	1.47
9.2	16.3	7.1	15.4	1.73	1.35	2.15 Average

Occurrence--Limestone Hills, Townsend, Montana, in the lower 3 feet of the Jefferson limestone.

Spirifer cf. S. jasperensis Warren

Plate 1, Figs. F, G, H, I, J

1940. Spirifer argentarius Warren, Meek and Merriam, Geol. Soc. Am. Spec. Paper 25, p. 87, figs. 5-11.
1947. Spirifer jasperensis Warren, Laird, Jour. Paleo. vol. 21, no. 5, p. 457, pl. 64, figs. 23,24.

Original Description--"shell small, subtrigonal in outline, hinge-line generally extended. Pedicle valve more strongly convex than the brachial valve; beaks of the pedicle valve high and generally strongly arched; cardinal area broadly triangular and arched. Sinus moderately deep, subangular to rounded in the bottom and without costae. Fold flattened with occasionally a faint furrow in the center. Costae usually from eight to twelve on either flank, well rounded and becoming faint toward the cardinal extremeties, with fine radiating striae superimposed upon them. Costae bounding the sinus usually much more prominent than others. Dimensions of an average shell;-width 15 mm, length 8 mm, convexity both valves, 7 mm." (1, p. 245)

Remarks--This is one of the most abundant brachiopods found at Logan; however, specimens of it are small and differ greatly in the convexity of the ventral valve and in height of area. (See plate 1, figs. I, J)

The ventral valve is subtrigonal to trigonal, highest and most convex at the umbonal region. The plications are simple, ranging in number from 5 to 10 on each slope, with the one next to the sulcus the most prominent. Increasing in width from the beak to the anterior margin, the sulcus is shallow and subround and shows no sign of plications. The beak is incurved and in one specimen is over hanging the cardinal area. The cardinal area is small, very low to medium height, and triangular to subtriangular in shape.

The dorsal valve is less convex than the other and carries a median, flattened fold that increases in width from the beak to the anterior margin and sometimes a median furrow. Costae on the valve are the same as on the other. The composition of the shell is fibrous calcite.

In the following table measurements and ratios are given for a number of specimens.

Thickness	Width	Length	Height	Length to Width	Length to Thickness	Height Area to Length
8.2	14.4	9.3	2.2	1.55	1.13	4.20
6.2	8.2	7.5	2.2	1.68	1.20	3.40
6.0	10.8	7.5	2.4	1.44	1.25	3.12
3.4	6.4	5.7	1.5	1.05	1.67	3.80
---	10.8	7.4	---	1.46	----	----
2.8	6.9	4.4	1.3	1.57	1.57	3.14
---	8.0	5.0	1.4	1.56	----	3.56
4.4	8.8	5.9	1.5	1.49	1.34	3.90
4.0	9.9	6.5	1.3	1.52	1.62	5.0
8.6	17.2	11.6	3.6	1.48	1.35	3.22
5.8	11.3	6.8	2.2	1.68	1.17	3.10
---	8.2	5.1	---	1.60	----	----
5.5	8.9	6.0	1.96	1.5	1.37	3.64 Average

There is little, other than size, to distinguish this species from Spirifer raymondi which is found in the same horizon. The surface features of the shells are quite similar to Spirifer engelmanni, and according to Laird (12, p. 457) "This high cardinal area plus curved beak of the ventral valve serve to differentiate this form from the previously mentioned species." The specimens at hand, as stated before, show a great variation in height of area and convexity of the ventral valve; therefore, some specimens were arbitrarily placed in this species. Laird gives the ratio of the length to the width of shell as 1.55, an average width 5.8 mm, an average length 9.0 mm, and for Spirifer engelmanni, an average width 11.5 mm, and an average length 6.25 mm. From specimens of S. engelmanni from the Limestone Hills of Townsend, the average ratio of length to width is 1.73, length of shell to height of area is 1.35, average width 16.3 mm, and average length 9.2 mm. From the above table it is seen that the size agrees more readily with S. jasperensis as does the average ratio of the length to the width. A closer look shows that this ratio ranges from 1.05 to 1.68. The average ratio of the height of area to the length of the shell, as shown above, is 3.64, and that for S. engelmanni is 1.35. This difference would seem to indicate that these specimens are not S. engelmanni but

probably S. jasperensis. If the above can be used for positive identification of this species it is then apparent that the height of area and the convexity of the ventral valve are quite variable.

Occurrence--75 feet above the base of the Jefferson limestone at Logan, Montana.

Genus Cyrtina Davidson, 1858

Cyrtina cf C. triquetra (Hall)

Plate 1, 2, Figs. K, L, A, B, C

1858. Cyrtina triquetra (Hall), Geol. Survey Iowa, I, P & II, p. 513.
1868. Cyrtina triquetra (Hall), Meek, Trans. Chicago Acad. Sci., I, p. 99.
1868. Cyrtina triquetra (Hall), Meek and Worthen, Geol. Surv. Ill, III, p. 436, pl. 13, fig. 4.
1895. Cyrtina triquetra (Hall), Hall and Clarke, New York Geol. Survey Paleontology, vol. 8, pt. 2, pl. 28, figs. 34, 35.
1897. Cyrtina triquetra (Hall), Schuchert, U.S. Geol. Survey Bull. 87, p. 199.

Description--"Shell small, very unequally biconvex, wider than long, broadest along the hinge line or anterior to it, a little extended at the cardinal angles in youthful specimens, and less produced than in the later stages. Dimensions of several hypotypes are: length of brachial valve 6.8 mm., 7.2 mm., 7.3 mm. and 8.6 mm.; width 10.4 mm., 10.5 mm., 12.8 mm., and 13.1 mm.; thickness 7.5 mm., 9.1 mm., 9 mm. and 10.6 mm. A pedicle valve measures 9.6 mm. in length, 13.7 mm. in width and 10.4 mm. in depth. Larger specimens also occur. Usually examples from one zone are nearly all the same size.

Pedicle valve strongly subpyramidal, highest at the beak, the surface sloping abruptly thence to the front and lateral margins, gently curved along the bottom of the sinus from the anterior margin to the beak. Mesial sinus extending the full length of the valve, strong, deep, angular along the bottom, the sides merging outwardly with the bounding plications, the front portion forming a short lingual extension. Slopes gently curved from the cardinal margin toward the front and from the sinus to the angles. Plications simple, continuing from the margins to the beak, narrow, of moderate size, rounded to subangular at the summit, separated by narrower furrows, decreasing in size away from the sinus and numbering about eight to ten. Beak highly elevated, generally twisted, sharply pointed, sometimes strongly or not at all curved. Palintrope high, usually wider than high, but higher than wide in some examples, flat or gently curved near the beak, apsacline, catacline, and even procline, horizontally and vertically striated; lateral margins sharply angular, nearly straight from the beak to the extremities. Delthyrium narrowly triangular, covered except near the apex by broadly convex deltidium.

Brachial valve subquadrate in outline, with the lateral margins straight or gently curved and making a right

angle with the hinge line, nearly flat and gently convex transversely in the middle. Mesial fold originating at the beak, becoming wider and higher more rapidly near the front, elevated above the remainder of the valve, strongly convex, flattened a little along the crest and showing there in numerous specimens a faint indication of a mesial sinus, the sides sloping abruptly to the bordering furrows, which are deeper and wider than those between the plications. Lateral slopes very gently curved in the posterior portions and from the fold to the lateral margins, bearing plications similar to those of the opposite slopes. Umbonal region gently convex; beak short, blunt. Surface of both valves marked by numerous fine lines of growth, occasionally lamellose. Punctae are scattered, not always readily apparent.

In the neanic stage the cardinal angles are slightly extended, the area flat and even retrorse and much wider than high, the fold with no indication of a median sinum and sinus without a plication. in the later stages the angles are not extended, the greatest width is anterior to the hinge-line; the palintrope is often higher than wide, curved, and inclined posteriorly; There is more indication of a mesial sinus on the fold and a plication in the pedicle sinus." (19, p. 446)

Remarks--Only two specimens of this species were found. Neither of these specimens shows punctae; however, Stainbrook (19, p. 44) states "Punctae, not always readily apparent." To be certain of classification, the internal structure should be studied. Dimensions of the specimens are as follows: length, 9.6 mm, 5.8 mm; width, 11 mm, 8.1 mm; thickness 8.3 5.5 mm; height of area, 6.5 mm, 4.0 mm; and width of area, 10.6 mm, 7.3 mm. Ratios are as follows:

Shell Length to Width	Length Shell To Height Area	Length to Thickness	Area Height to Width	
1.15	1.69	1.15	1.70	
1.39	1.45	1.05	1.83	
1.27	1.57	1.10	1.76	Average

The ventral valve is strongly subpyramidal, highest at the beak, with a sulcus round to subround, shallow, increasing in width from the beak to the anterior margin. The ventral valve is more convex than the dorsal and carries simple plications, numbering about 10 to 11 on each side of the sulcus. The cardinal area is procline, and in one specimen the beak is twisted. The dorsal valve is nearly flat with the greatest convexity in the center of the valve and with plications as on the other

valve. The fold is prominent but low and nearly flattened.

There seems little to distinguish this species from Spirifer engelmanni, except smaller size, procline cardinal area, and punctae (which are not apparent). The placing of these two specimens into this species is rather doubtful, and there is a strong possibility that they represent an immature Spirifer engelmanni rather than another species. This species is reported from other localities at the same horizon, but none have been reported from the Jefferson limestone in Montana.

Occurrence--The lower 3 feet of the Jefferson limestone, Limestone Hills, Townsend, Montana.

Superfamily ROSTROSPIRACEA

Genus Athyris McCoy, 1844

Athyris parvula Whiteaves

Plate 2, Figs. D, E, F

1891. Athyris parvula Whiteaves, Cont. Canadian Pal., I, p. 228, pl. 32, figs. 4,5.

"The largest has a length and breadth of 9 mm., and has the fold and sinus rather more prominently developed than indicated in Whiteaves figures. The smallest specimen measures 4 mm. in width and 4½ mm. in length. This shell shows no trace of the fold and sinus characterizing the mature shells. A slightly larger specimen shows the fold and sinus barely perceptible beyond the anterior margin of the shell, where they are distinctly marked." (10, p. 29)

Remarks--The shell is small, subcircular in outline, equally convex, wider than long, and with the greatest width anterior to the hinge line. Dimensions are as follows: length, 3.8 mm; width, 4.0 mm; and thickness, 2.1 mm.

The pedicle valve is smooth except for fine costae at the anterior margin, numbering 8 to 10 per mm. A faint sinus is present at the anterior margin; however, it is not well defined. The convexity is greatest at the umbonal region. The beak is broken off but appears to be small

as is the cardinal area. The hinge line is curved.

The brachial valve is round in outline, showing no costae at the anterior margin and no indication of a fold. The greatest convexity is at the umbonal region. The beak is small and incurved.

Only one specimen was found, and it is badly exfoliated. The shell substance is clear, brownish, fibrous, and aragonite or calcite.

Occurrence--In the lower 3 feet of the Jefferson limestone, in the Limestone Hills, Townsend, Montana.

Superfamily ATRYPACEA

Genus Atrypa Dalman, 1827

Plate 2, Figs. G, H, I, J

1868. Atrypa Dalman, Meek and Worthen, Geol. Survey of Ill., vol. 3, p. 432, pl. 13, fig. 11.
1884. Atrypa Dalman, Walcott, Monograph U. S. Geol. Survey, vol. 1, p. 90, pl. 13, fig. 9.

> Description--"Shell subcircular or longitudinally suboval in outline. Gibbous, strongly inequivalved. Hinge-line short, straight; cardinal extremities rounded. Beak not prominent. Pedicle valve the smaller; convex in the umbonal region, but depressed and often deeply sinuate anteriorly....
>
> Brachial valve convex or rotund in the middle, with a median fold which is rarely developed except toward the anterior margin. Beak incurved and concealed. No cardinal area....
>
> External surface covered with radial plications crossed by concentric growth-lines...Shell-substance fibrous, impunctate." (6, p. 164)

Atrypa sp.

Remarks--The shells are small, subcircular in shape, unequally convex, slightly wider than long, and asymmetrical, with the right side elongate. For two well preserved specimens the length is 13.0 mm, 12.1 mm, width 11.5 mm, 12.5 mm, thickness 6.3 mm, 5.8 mm, and for one small species questionably placed in this group, length 5.9 mm, width 7.3 mm, thickness 3.6 mm.

The ventral valve is not as convex as the dorsal, with the greatest convexity at the umbonal region. Starting 3 mm anterior from the beak

and widening to the anterior margin, the mesial sinus is distinct and shallow. In another specimen the sinus is poorly defined. Plications are fine and present only at the anterior margin; this is due to exfoliation. The beak is low, pointed, and slightly curved; the area is small, subtriangular in shape and contains a round foramen. The hinge line is curved and short with the widest part of the valve anterior to it.

The dorsal valve is more convex than the ventral with the greatest convexity in the middle of the valve and showing no sign of a fold. The beak is well incurved into the ventral valve. Fine bifurcating costae are present near the anterior margin; also prominent growth lines parallel with the anterior margin, which are more numerous than on the other valve. Both valves have fine costae averaging about 7 in number per 4 mm along the anterior margin.

Occurrence--The lower 3 feet of the Jefferson limestone at Limestone Hills, Townsend, Montana.

Atrypa missouriensis Miller

Plate 2, 3, Figs. K, L, A, B

1908. Atrypa missouriensis Miller, Kindle, Bull. Am. Paleontology, vol. 4, no. 20, p. 29, pl. 1, figs. 7-7b.
1947. Atrypa missouriensis Miller, Laird, Jour. Paleo., vol. 21, no. 5, p. 457, pl. 64, figs. 19-22.

> Original Description--"Shell small, subcircular, rather longer than wide, valves very moderately and nearly equally convex, cardinal extremities rounded.
>
> Ventral valve most convex in the umbonal region, which is rather sharply rounded, transversely, from which elevation the shell gently slopes to the front and the antero-lateral sides. Beak projects a little beyond the beak of the opposite valve, but is not incurved over it.
>
> Dorsal valve rather more evenly convex than the ventral, without any defined mesial elevation, the greatest convexity being in the central part, from which it slopes nearly equally in all directions. Beak very small extending slightly beyond the cardinal line, but not incurved.
>
> Surface marked by numerous very fine radiating striae that are crossed by a few concentric lamellose lines of growth." (13, p. 315)

Remarks--This species is very abundant and badly exfoliated as well as

smashed along the anterior margin. They are small and have an average of 50 to 70 fine bifurcating costellae. The majority of the specimens are not as thick as those described by Laird (12, p. 457), but this is due to their flattened condition. Two specimens that are not flattened agree with the thickness that Laird gives. Specimens show a greater convexity in the umbonal regions. Very indistinct growth lines were noticed on a few specimens and on some an indistinct sinus.

The cardinal area is small, and the hinge line is curved. The dorsal valve is more equally convex, and the beak is incurved.

The following table shows the dimensions and ratios of a number of complete specimens.

	Length	Width	Thickness	Ratio Length to Width	Ratio Length to Thickness	
1.	10	10	7	1.0	1.4	
2.	10.5	10	5.2	.95	2.0	
3.	11.0	10	4.0	.91	2.7	
4.	9.2	9	3.8	.98	2.4	
5.	8.6	8.3	3.5	.97	2.4	
6.	8.5	7.8	4.5	.92	1.9	
7.	8.8	7.7	3.0	.88	2.9	
8.	9.0	8.0	2.4	.89	3.7	
9.	8.7	8.7	3.9	1.0	2.2	
10.	9.4	9.5	3.3	1.0	2.8	
11.	11	10.7	4.0	.97	2.7	
12.	9.7	----	4.6	----	2.1	
13.	8.0	----	3.1	----	2.6	
14.	9.2	8.2	3.2	.89	2.8	
	9.2	8.9	3.9	.95	2.5	Average

Shell substance fibrous calcite.

Occurrence--The lower 3 feet of the Jefferson limestone at Limestone Hills, Townsend, Montana.

Superfamily STROPHOMENACEA

Genus Schuchertella Girty

Schuchertella chemungensis var. arctostriata (Hall)

Plate 3, Figs. C, D, E

1843. Strophomena chemungensis (Hall), Conrad, Jour. Acad, Nat. Sci. Philad., vol. VIII, p. 257, pl. 14, fig. 12.

1863. Streptorhynchus arctostriatus (Hall), Hall, Sixteenth Report Regents Univ. New York on State Cab., N. H. 62.
1877. Hemipronites chemungensis var. arctostriatus (Hall), King, U. S. Geol. Exploration of the Fortieth Parallel, pt. IV, p. 35.
1908. Schuchertella chemungensis var. arctostriata (Hall), Kindle, Bull. Am. Paleont., vol. 4, p. 26.

> "Shell semicircular or semiellipical, frequently unsymmetrical, the proportions of length and breadth varying in different individuals: hinge-line straight, nearly or quite equal to or greater than the greatest width of the shell; sides nearly rectangular to the hinge-line, or curving inwards. Ventral valve more or less convex towards the umbo and sometimes in the middle, curving downwards or flattened towards the front and sides of the shell: beak often distorted; area vertical or inclined forwards or backwards, usually unequal on the two sides of the foramen, which is closed by a strong convex deltidial plate. Dorsal valve depressed convex, sometimes nearly flat and sometimes very convex, with a narrow linear area: socket-plates strong, and supporting the cardinal process, which is double and has sometimes a faint ridge between the two divisions, which are themselves very short.
>
> Surface marked by sharp close radiating crenulated striae, which increase mainly by interstitial additions.... This species is represented by individuals varying from one-fourth to three-fourths of an inch in length, and having a width of from one-fourth to one third greater than the length...The convexity of the ventral valve is very variable: the extent of the area is likewise subject to much variation; and the beak is sometimes symmetrical, and varies from extreme distortion to a scarcely perceptible obliquity of the apex. In some specimens there are strong llamellose lines of growth, and in others these lines are scarcely visible. The dorsal valve varies from nearly flat to very convex; and some specimens the length and breadth are almost equal, while the cardinal process is scarcely developed beyond the plain socket-plate, which is bent outwards, and sometimes scarcely divided at the apex. The surface striae are, in some specimens, more rounded and pretty equally developed, while in others they are very sharp and unequal." (7, p. 71)

Remarks--This species is quite abundant, but no specimens were found containing both valves; generally only the ventral valve was preserved, but some impressions were found of the dorsal valve which appears to be flat. This species varies greatly in size, but other characteristics remain the same. The costae increased mainly by interstitial additions. None of the specimens found showed any indication of a sinus which differentiates this type from Schuchertella

coloradoensis. The table below shows dimensions and ratios of a number of ventral valves.

Area				Ratio	
Width	Length	Height	Width	Length to Width	Height to Width
11	9.5	3.5	9.0	1.16	3.13
14.4	11	4.4	12.6	1.31	3.27
14.4	12.0	4.4	11.7	1.2	3.27
17.0	11.6	3.4	12.6	1.46	5.0
----	----	4.4	14.0	----	----
11.4	9.7	3.8	11.0	1.18	3.0
5.9	4.2	2.0	5.6	1.40	2.96
12.5	9.7	3.7	10.9	1.31	2.6 Average

If the brachial valves are flat or nearly so, the length would correspond approximately to the height of the cardinal area. The cardinal area of all specimens is vertical or apsacline, and appears to stand at right angles to the hinge line of the valves. Shell substance calcite.

Occurrence--75 feet from the base of the Jefferson limestone, at Logan, Montana.

PHYLUM COELENTERATA

Class STROMATOPOROIDEA

Clathrodictyon Nicholson and Murie 1878

Clathrodictyon laxum Nicholson

Plate 3, Figs. F, G, H

1877. Clathrodictyon laxum Nicholson. Ann. and Mag. Nat. Hist., pp. 12-13, pl. III, figs. 4-5.
1904. Clathrodictyon laxum Nicholson, Parks. Rept. Ont. Bureau of Mines, vol. XIII, pt. 1, p. 183.

Description--"Nicholson's description of this species is as follows: 'Coenosteum laminar or incrusting, a basal epitheca being present in the former case. Upper surface smooth or slightly undulated, without 'mamelons', and apparently covered with small tubercles. Astrorhizae apparently wanting.

'As regards internal structure, the skeleton is composed of horizontal or slightly flexuous concentric laminae, of which about four are placed in the space of 1 mm. (there are usually three interlaminar spaces in 1 mm.) The laminae are comparatively thin, and are not crumpled or inflected. The interlaminar spaces are crossed by numerous delicate vertical radial pillars, most of which reach from one lamina to the next. Tangential

sections exhibit the oval or rounded cut ends of the radial pillars along with sinuous edges of the transversely divided laminae. Astrorhizae may be present but were not seen in the specimens examined.'

The examination of a large number of specimens shows that this species is extremely variable, not only in different coenostea, but in different parts of the same specimen. In most specimens the average width of an interlaminar space is about 0.4 mm., but both narrower and wider interspaces occur. A characteristic feature of the species is the presence of extremely thin arched "interlaminar septa", in places extending considerable distances and crossing several pillars." (14, p. 13)

Remarks--This species is abundant but not easily recognized in the field. No complete specimen was found - just fragments.

The animal, hemispherical in shape, is made up of concentric laminae that average about 4 per mm. These laminae are divided by vertical, thick, non-bifurcating, irregularly spaced, pillars that generally connect only one interlaminar layer; however, a few pillars connect two or three interlaminar layers. The tangential section shows the end of the pillars as dots and the edges of transversely divided laminae. Spacing of these dots is irregular.

This species resembles closely Clathrodictyon substriatellum, but differs in that the pillars are non-bifurcating, the spacing of the pillars is wider, the laminae are more closely spaced, and the pillars have greater diameters.

Occurrence--75 feet from the base of the Jefferson limestone, Logan, Montana.

Class ANTHOZOA

Genus Favosites Lamark 1816

Favosites cf F. limitaris Rominger

Plate 3, Figs. I, J

1876. Favosites limitaris Rominger, Fossil Corals, Geol. Surv. Michigan, vol. III, pt. 2, p. 36, pl. 13.
1883. Favosites limitaris Rominger, Hall, Indiana Dept. Geol. Nat. Hist., 12th Ann. Rept., pp. 256-257, pl. 4, figs. 5, 6.
1885. Favosites limitaris Rominger, Davis, Kentucky Fossil Corals, p. 30, pl. 31, fig. 1.

1909. Favosites limitaris Rominger, Grabau and Shimer, North American Index Fossils, I, p. 88, fig. 142.

Description--"Ramified and reticulated stems, from five to fifteen millimeters in thickness, forming horizontally explanate expansions or erect fruticose ramifications. Tubes very thick-walled, opening nearly rectangularly to the surface, with circular orifices, the walls forming either a solid, undefined interstitial mass, or in another state of preservation, the polygonal outlines of each tube are visible on the surface of the interstices as delicate engraved lines. Several varieties are observed in regard to the mode of growth and size of the tubes. The tube orifices rarely exceed the diameter of one millimeter; often they are smaller, and in some forms they are all equal in a specimen; others have smaller and larger orifices intermingled. A part of the orifices on the side faces of the stems are often found closed by opercula, situated below the outer edge of the channels; in the interior parts of the tube channels diaphragms are not regularly developed, and are of rare occurrence. Pores, large, distant, and irregularly dispersed. In older stems the tube channels are not unfrequently become considerably narrowed by excessive incrassation of the tube walls, while the pore channels gain in length and width, and appear on the surface as vermicular, transverse channels connecting the tube channels, which later are, in their narrowed condition, hardly larger than the connecting pore channels." (3, p. 54)

Remarks--Only one specimen was found, and the surface shows the typical honey-combed structure that is rectangular at the surface. Tubes are thick-walled, and their orifices over the surface vary in size with a maximum of 1 mm. Corallum is branched, circular in cross-section and the walls show tabulae in the form of ridges. No pores were noted on the specimens at hand.

Occurrence--75 feet from the base of the Jefferson limestone, Logan, Montana.

BIBLIOGRAPHY

1. Allan, J. A., P. S. Warren and R. L. Rutherford, "A Preliminary Study of the Eastern Ranges of the Rocky Mountains in Jasper Park, Alberta," Royal Society of Canada Trans., series 3, section 4, vol. 26, pp. 225-248, 1933.

2. Berry, G. W., "Stratigraphy At Three Forks," Bull. Geol. Soc. of America, vol. 54, pp. 1-30, 1943.

3. Buihiler, H. A., "The Devonian of Missouri," Missouri Bureau of Geology and Mines, vol. 17, 2nd series, 1923.

4. Corry, A. V., "Some Gold Deposits of Broadwater, Beaverhead, Phillips, and Fergus Counties, Montana," Montana Bur. Mines and Geol., Mem. 10, 1933.

5. Deiss, Charles F., "Paleozoic Formations of Northwestern Montana," Montana Bureau of Mines and Geol., Mem. 6, 1933.

6. Hall, James, Natural History of New York Paleontology, vol. 8, 1894.

7. _____, New York Geological Survey, vol. 4, pt. 2, 1867.

8. Hayden, F. V., Geological Report of The Exploration of the Yellowstone and Missouri Rivers, Gov't. Printing Office, 1869.

9. Haynes, W. P., "The Fauna of the Upper Devonian in Montana," Carnegie Inst. Mus. Ann., vol. 10, pt. 2, pp. 13-54, 1916b.

10. Kindle, E. M., "The Fauna and Stratigraphy of the Jefferson Limestone in the north Rocky Mountain Region," Bull. Am. Paleont., vol. 4, pp. 1-39, 1908b.

11. King, Clarence, U. S. Geological Exploration of the Fortieth Parallel, pt. 4, Gov't. Printing Office, 1877.

12. Laird, Wilson M., "An Upper Devonian Brachiopoda Fauna From Northwestern Montana," Jour. Paleo., vol. 21, no. 5, 1947.

13. Miller, S. A., Geol. Survey Indiana Eighteenth Ann. Report, 1893.

14. Pardee, J. T., "The Geology and Ground Water Resources of the Townsend Valley, Montana," U. S. Geol. Survey Water and Supply, paper 539, 1926.

15. Parks, W. A., "Devonian Stromatoporoids of North America," University of Toronto Studies, Part 1, Geol. series no. 39, pp. 5-125, 1936.

16. Peale, A. C., "The Paleozoic Section in the Vicinity of Three Forks, Montana," U. S. Geol. Survey, Bull. 110, 1893.

17. Ruppel, Edward T., "Geology of the Limestone Hills, Broadwater County, Montana," U. S. Geol. Survey, Open file, Aug., 1950.

18. Sloss, L. L., and W. M. Laird, U. S. Geol. Survey, oil and gas investigations, preliminary chart 25, 1946.

19. Stainbrook, Merrill A., "Spiriferacea of Limestone of Iowa," Journal of Paleo., vol. 17, no. 5, pp. 417-427, 1943.

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EXPLANATION OF PLATE I

Figs. A-E--*Spirifer engelmanni* Meek, Limestone Hills. A-anterior, B-posterior, C-lateral, views of the same specimen x 1.2, D-dorsal view x 1.0, E-ventral view x 1.0. (p. 5)

Figs. F-J--*Spirifer* cf. *S. jasperensis* Warren, Logan. All figures natural size. F, G-ventral views, H-dorsal view, I, J-lateral views showing variation in the height of area and convexity of the ventral valve. (p. 7)

Figs. K-L--*Cyrtina* cf. *C. triquetra* (Hall), Limestone Hills. K-anterior, L-dorsal, views of the same specimen x 1.7. (p. 10)

PLATE I

A

B

C

D

E

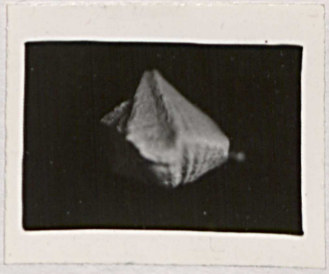
F

G

H

I

J



K

L

LOWER JEFFERSON FAUNA

EXPLANATION OF PLATE II

Figs. A-C--*Cyrtina* cf. *C. triquetra* (Hall), Limestone Hills. All figures enlarged about 1.7 times. A-lateral view of specimen in Plate I, figs. K-L; B-anterior, C-lateral, views of same specimen. (p. 10)

Figs. D-F--*Athyris parvula* Whiteaves, Limestone Hills. D-dorsal x 7, E-ventral x 7, F-anterior x 3, views of the same specimen. (p. 12)

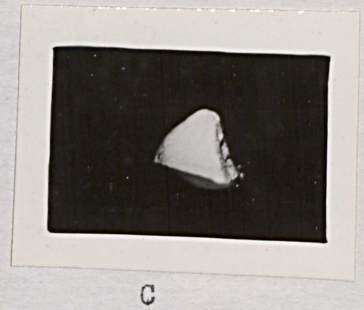
Figs. G-J--*Atrypa* sp., Limestone Hills. All figures enlarged about 1.2 times. G-dorsal view, H-ventral view, I-lateral view, J-anterior view. (p. 13)

Figs. K-L--*Atrypa missouriensis* Miller, Limestone Hills. K-lateral view, L-anterior view. (p. 14)

PLATE II

A

B



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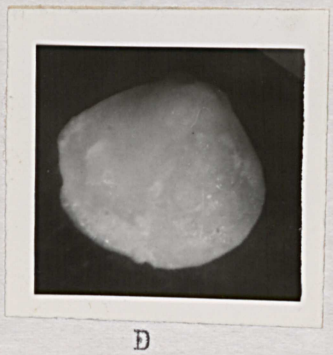

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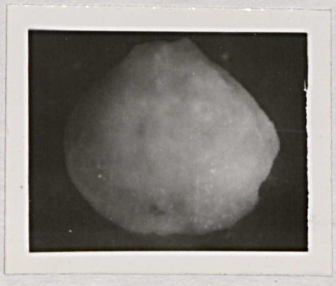


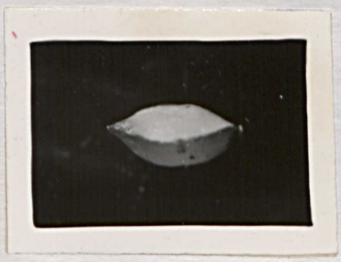
E

F

G

H

I



J

K

L

LOWER JEFFERSON FAUNA

EXPLANATION OF PLATE III

Figs. A-B--Atrypa missouriensis Miller, Limestone Hills. All views enlarged about 3 times. A-dorsal view, B-ventral view. (p. 14)

Figs. C-E--Schuchertella chemungensis var. arctostriata (Hall), Logan. C-ventral view x 1.7, D-lateral view x 1.0, E-impression of a dorsal valve x 1.0. (p. 15)

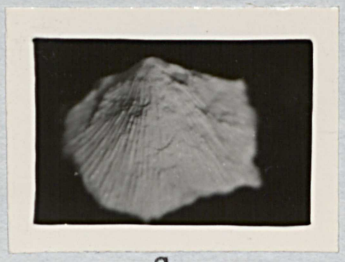
Figs. F-H--Clathrodictyon laxum Nicholson, Logan. All views enlarged 10 times. F-vertical section, G, H-tangential sections of fig. F. (p. 17)

Figs. I-J--Favosites cf. F. limitaris Rominger, Logan. Both views enlarged 7 times. I-top view, J-longitudional view. (p. 18)

PLATE III

A

B



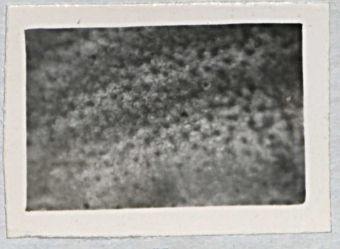
C

D

E

F

G



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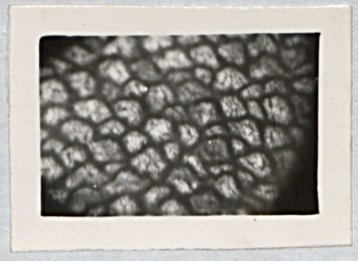

I

J

LOWER JEFFERSON FAUNA